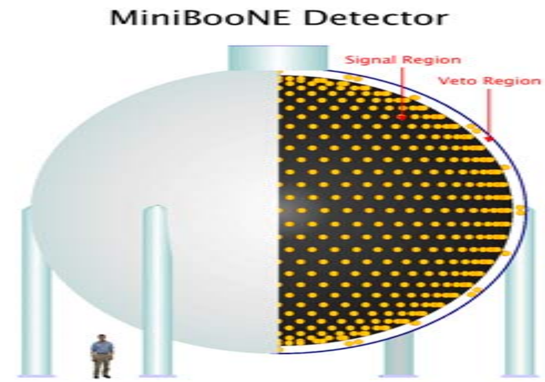
MiniBooNE at Fermilab



Light Transmission Properties of a Pure Mineral Oil Neutrino Detector

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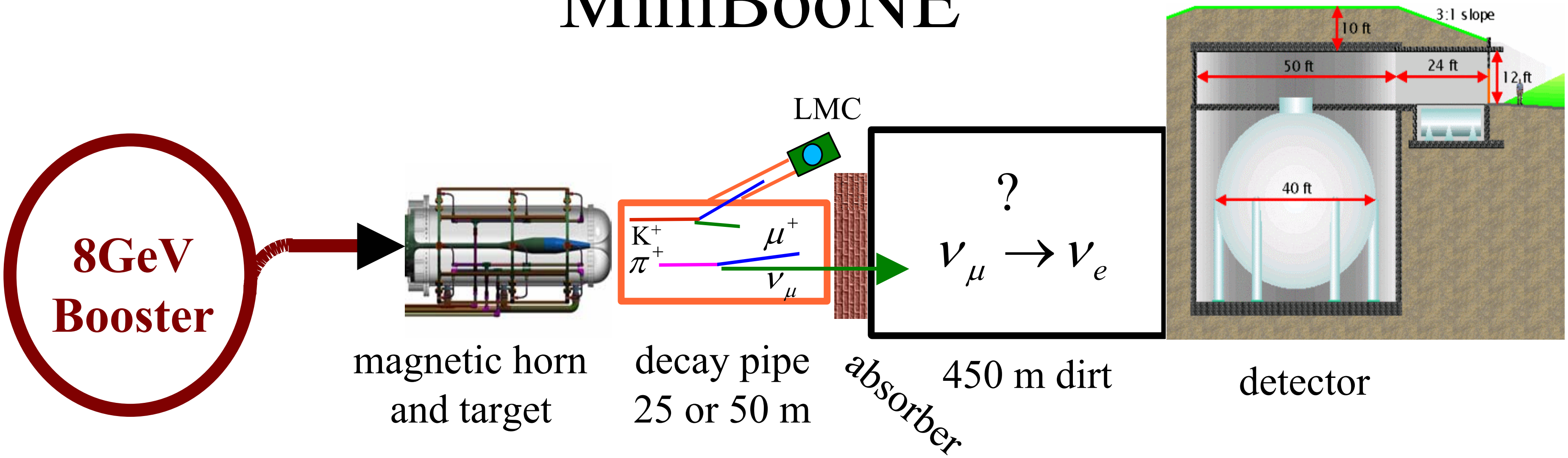
for the
MiniBooNE Collaboration (E898)

MiniBooNE



8-GeV protons on Be target →

π^+, K^+,…, focused by horn

decay in 50-m pipe, mostly to ν_μ

all but ν absorbed in steel and dirt

ν's interact in 40-ft tank of mineral oil

charged particles produce light

detected by phototube array

Look for electrons produced by mostly-ν_μ beam

The MiniBooNE detector

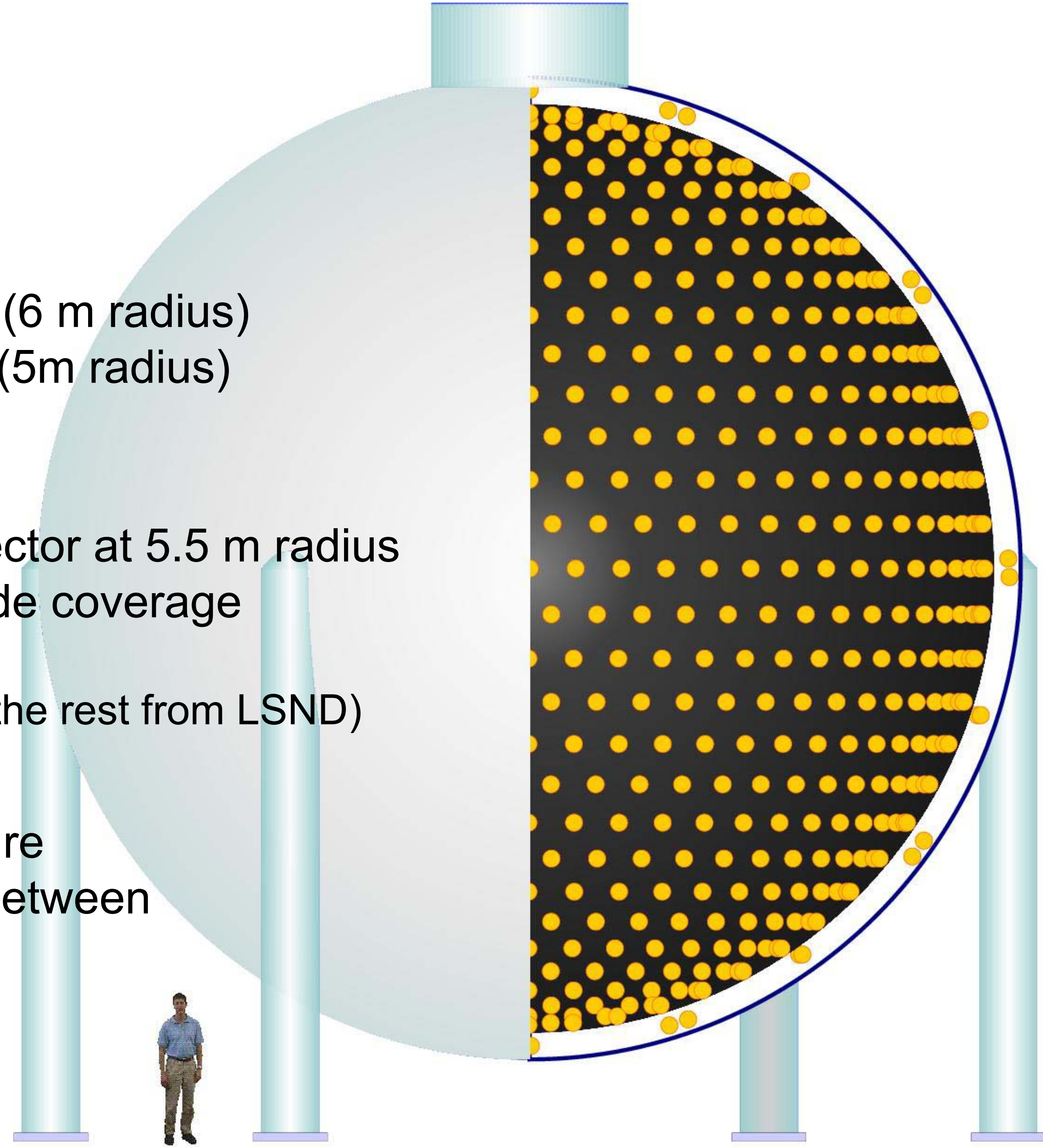
MiniBooNE detector

pure mineral oil

total volume: 800 tons (6 m radius)
fiducial volume: 445 tons (5m radius)

1280 20-cm PMTs in detector at 5.5 m radius
→ 10% photocathode coverage
240 PMTs in veto
(330 new tubes, the rest from LSND)

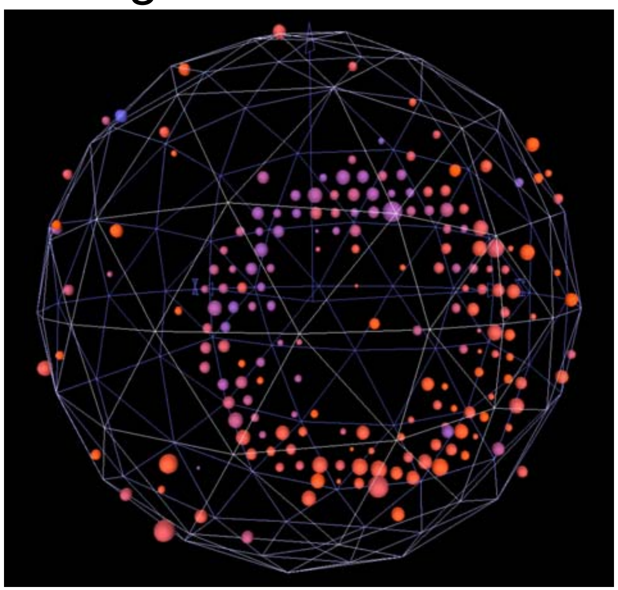
Phototube support structure
provides opaque barrier between
veto and main volumes



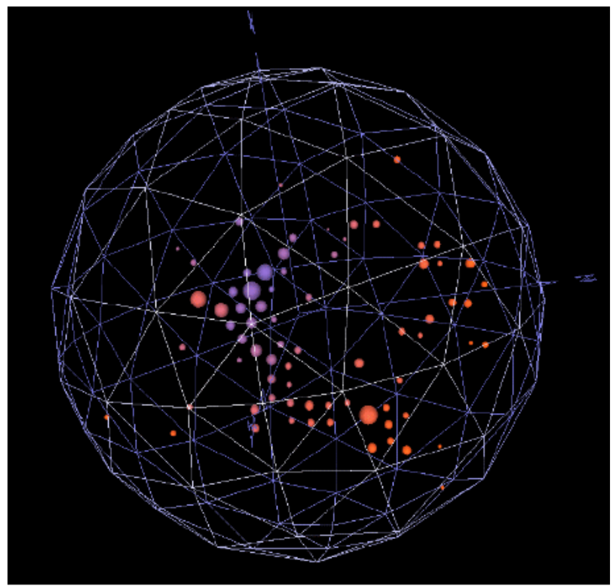
Pattern of hit tubes (with charge and time information)
allows reconstruction of track location and direction
and separation of different event types.

e.g. candidate events:

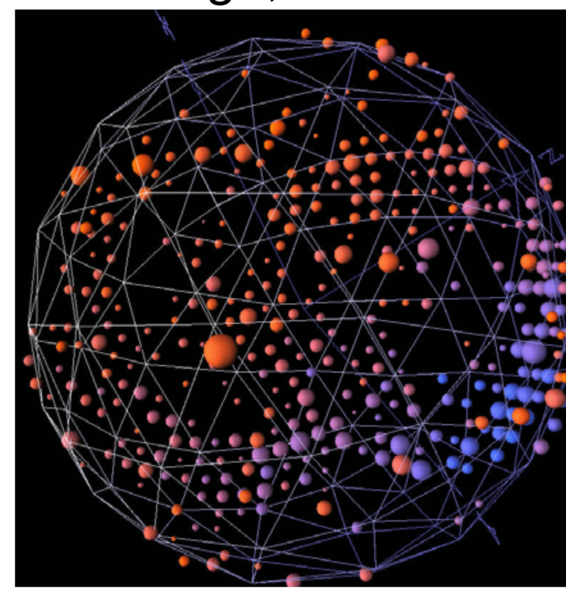
size = charge, color = time



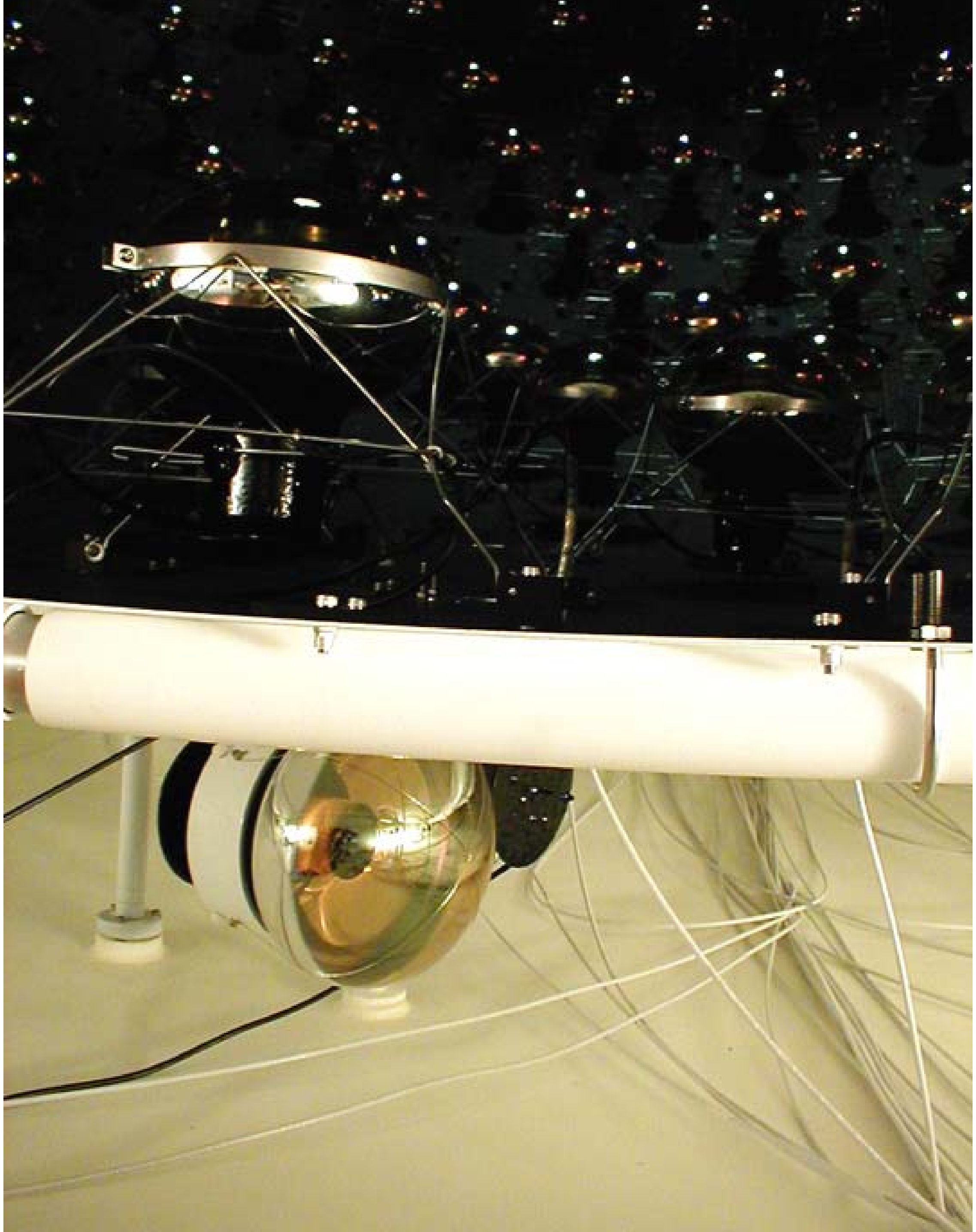
muon
from ν_μ interaction

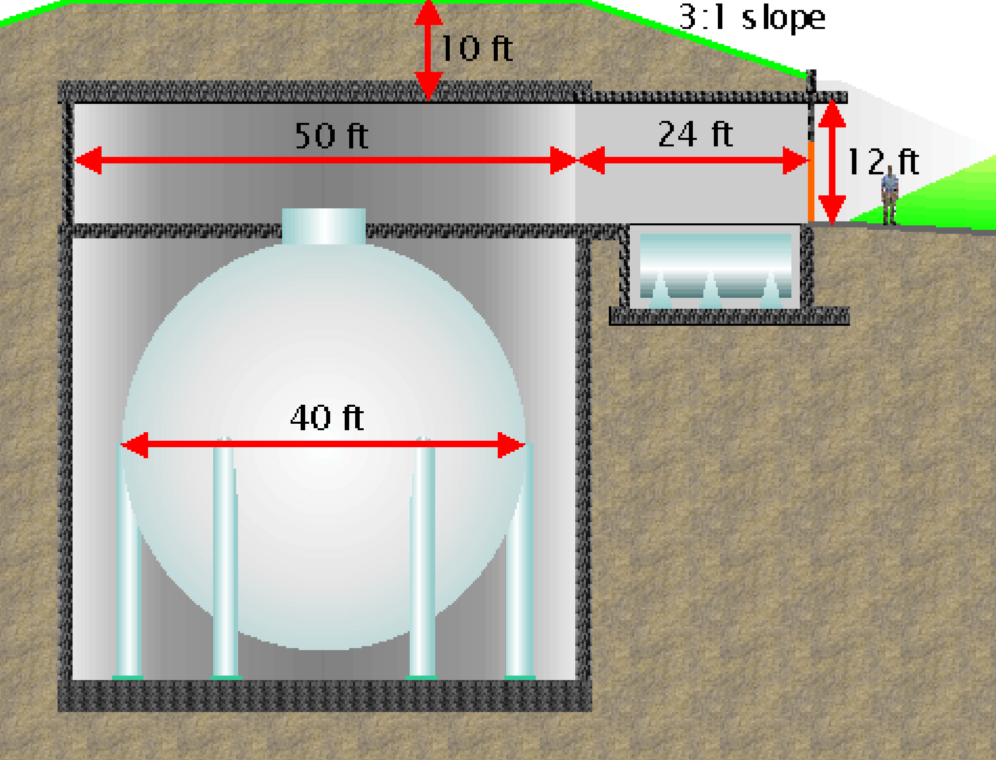


Michel electron
from stopped μ decay
after ν_μ interaction

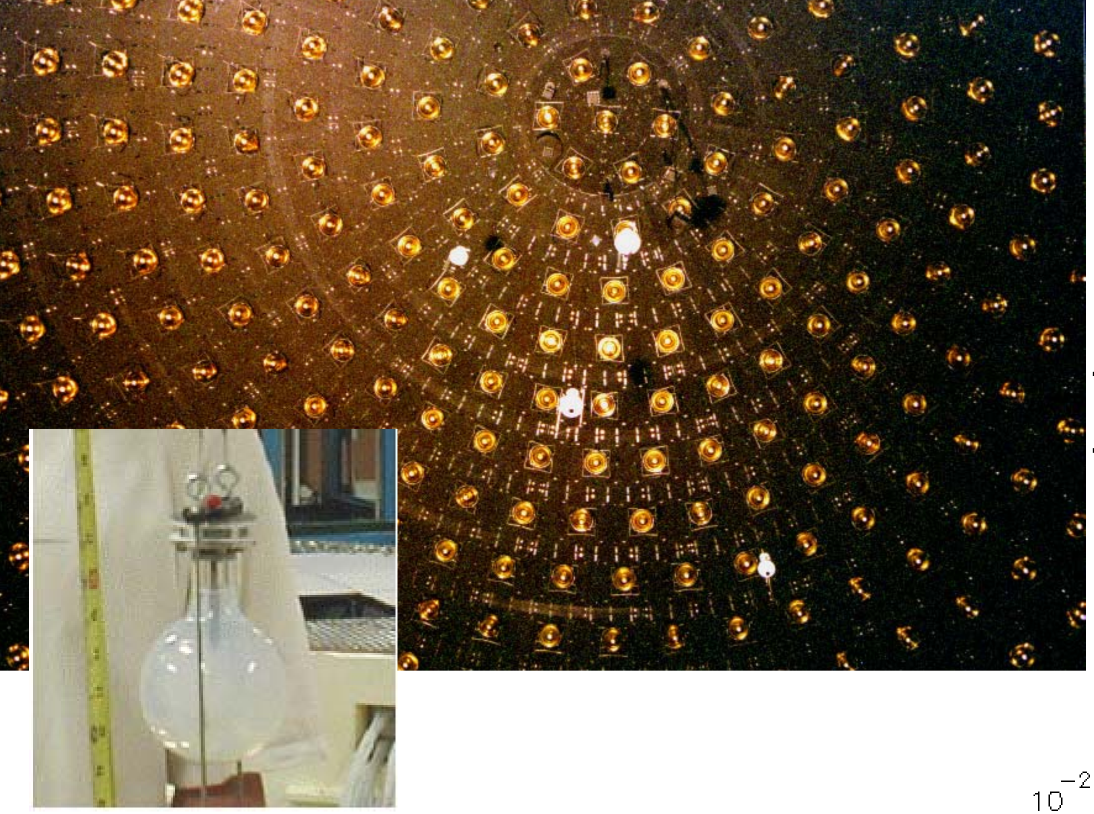


$\pi^0 \rightarrow$ two photons
from ν_μ interaction




3:1 slope
10 ft
50 ft
24 ft
12 ft
40 ft

Understanding the detector



Laser flasks

four Ludox-filled flasks
fed by optical fiber from laser

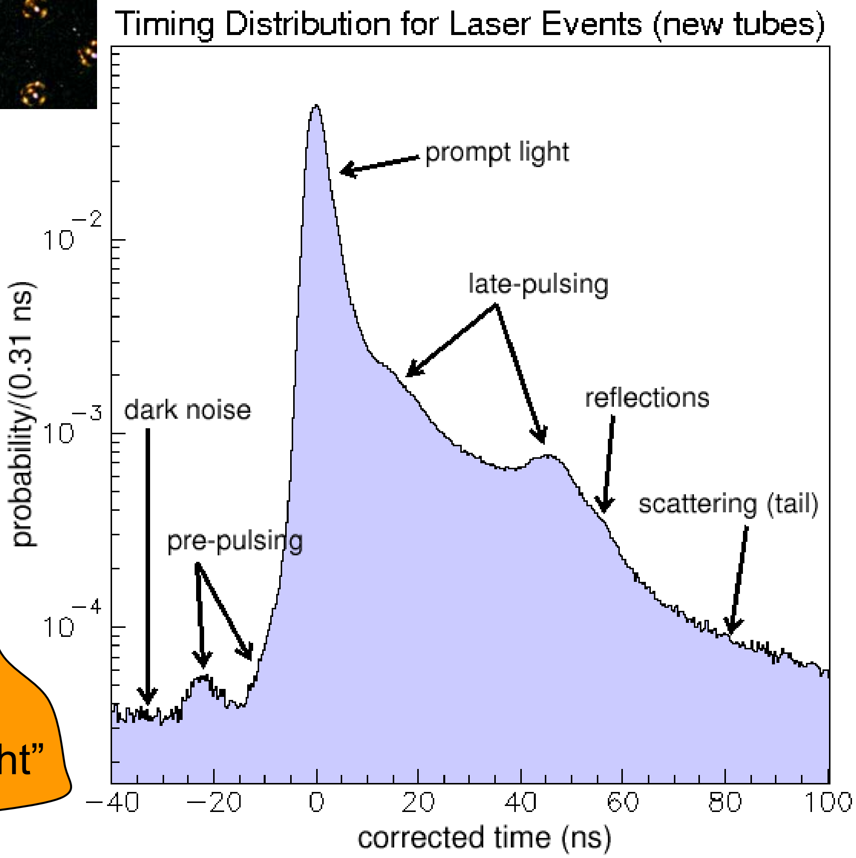
measure:

PMT charge and time response

and

oil attenuation length

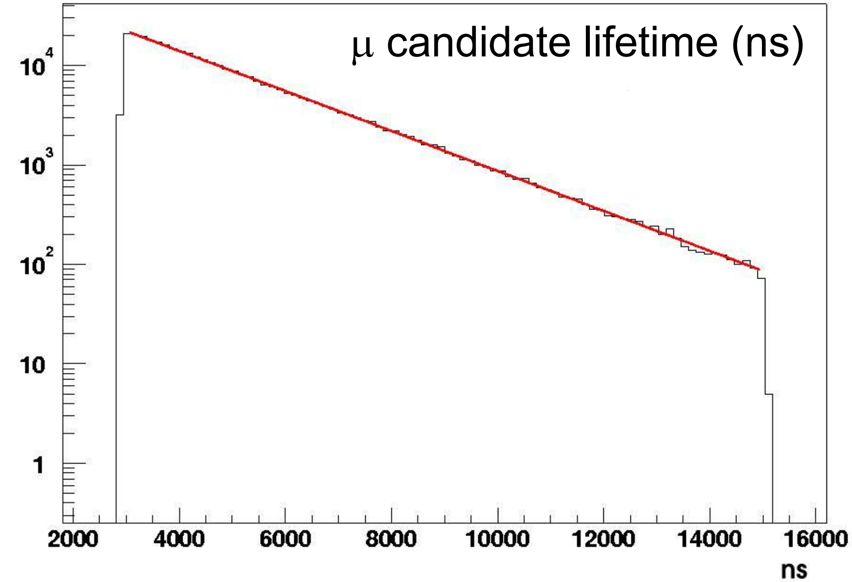
397 nm laser
(no scintillation!)
modeling other
sources of “late light”



Michel electrons

(electrons from the decay of stopped muons)

plentiful source from cosmics
and beam-induced muons



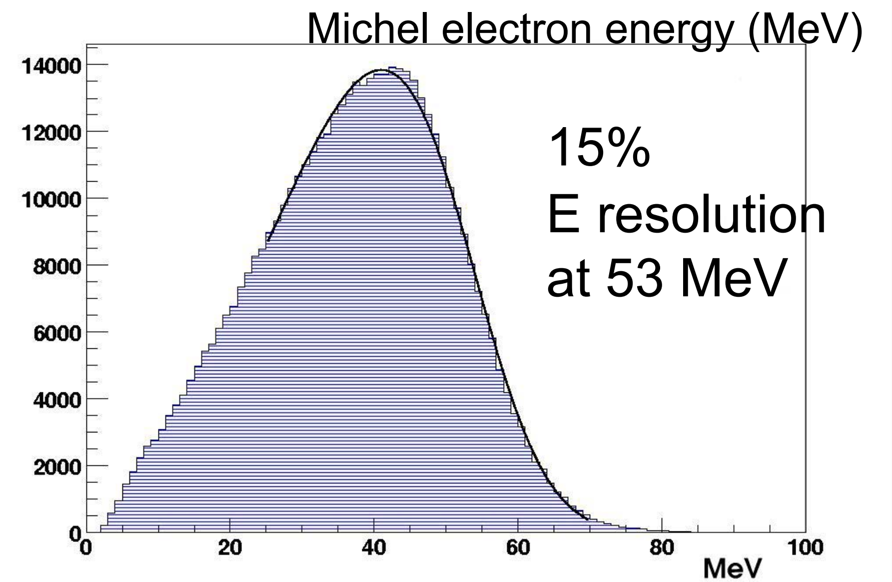
cosmic muon lifetime in oil

measured: $\tau = 2.15 \pm 0.02\ \mu s$

expected: $\tau = 2.13\ \mu s$

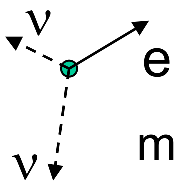
(8% μ^- capture)

Energy scale and resolution
at Michel endpoint (53 MeV)



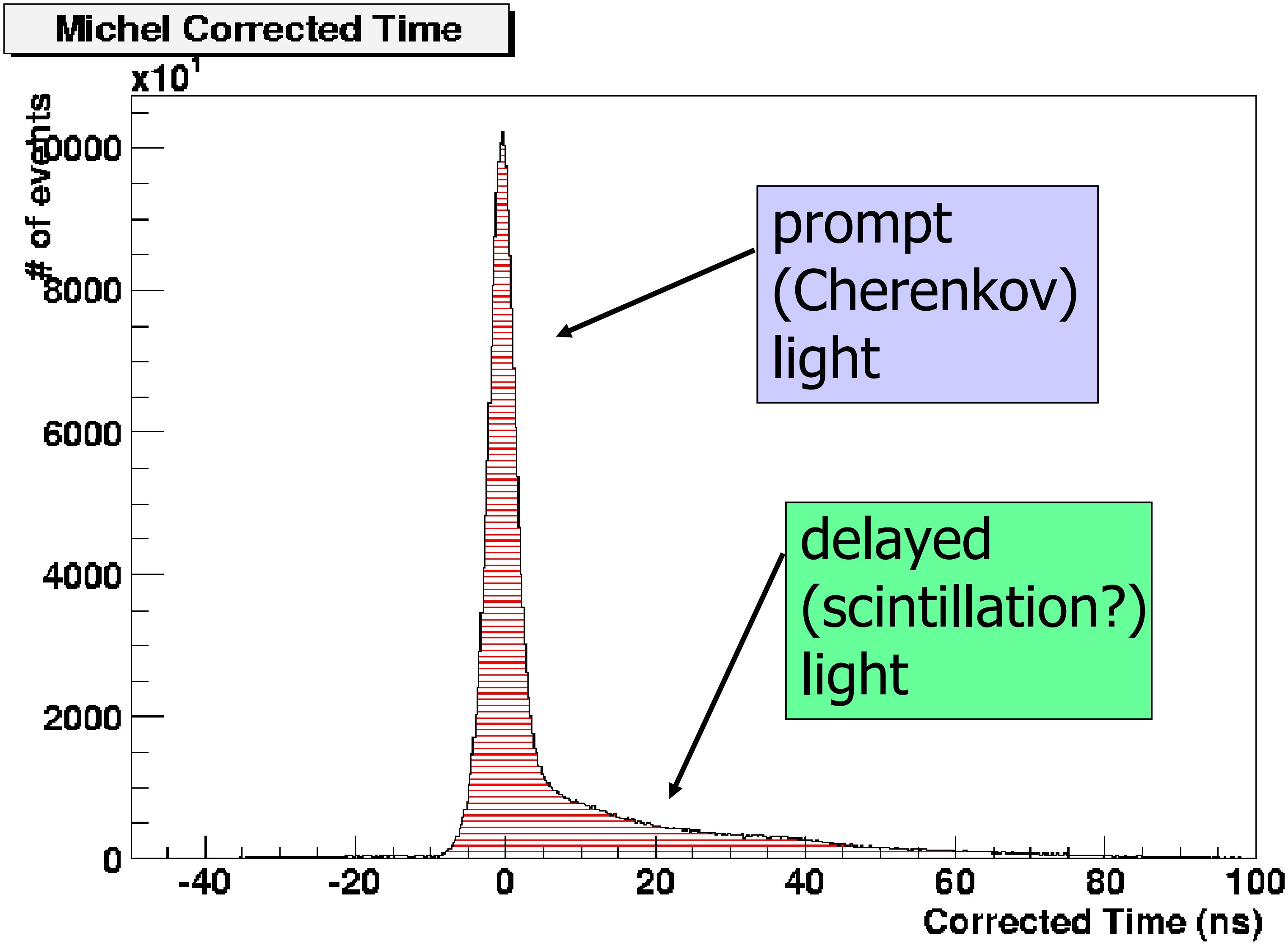
Michel electrons throughout
detector (r<500 cm)

Time spectrum of light from Michel electrons

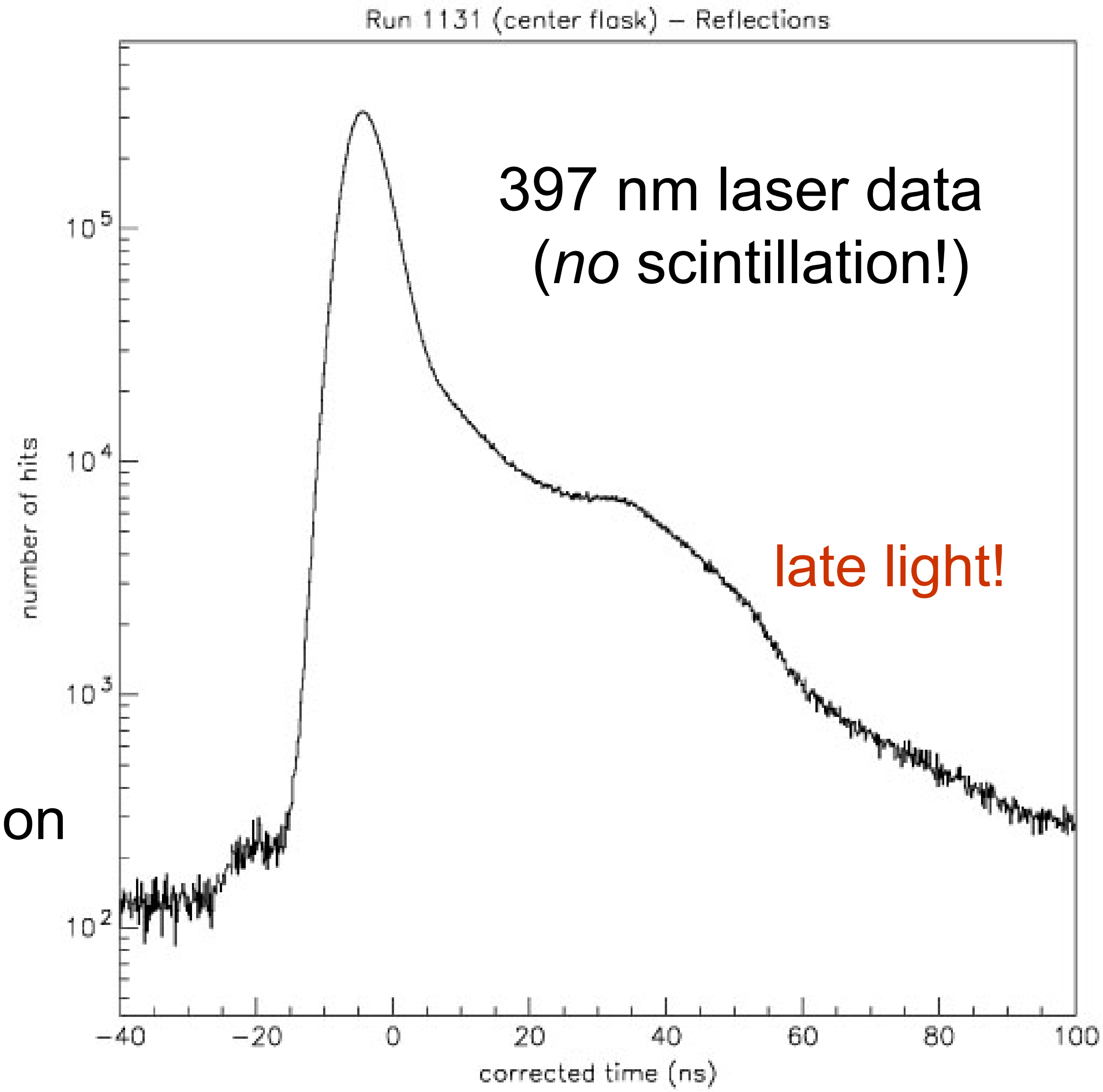


muon stops and decays

Measure, e.g., time resolution
scintillation time constant

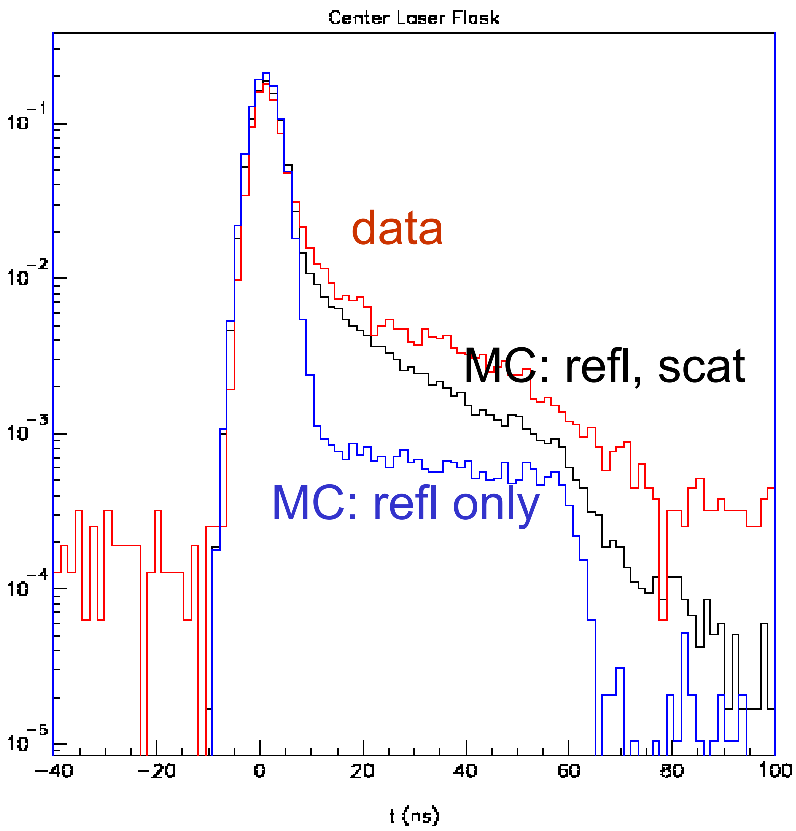


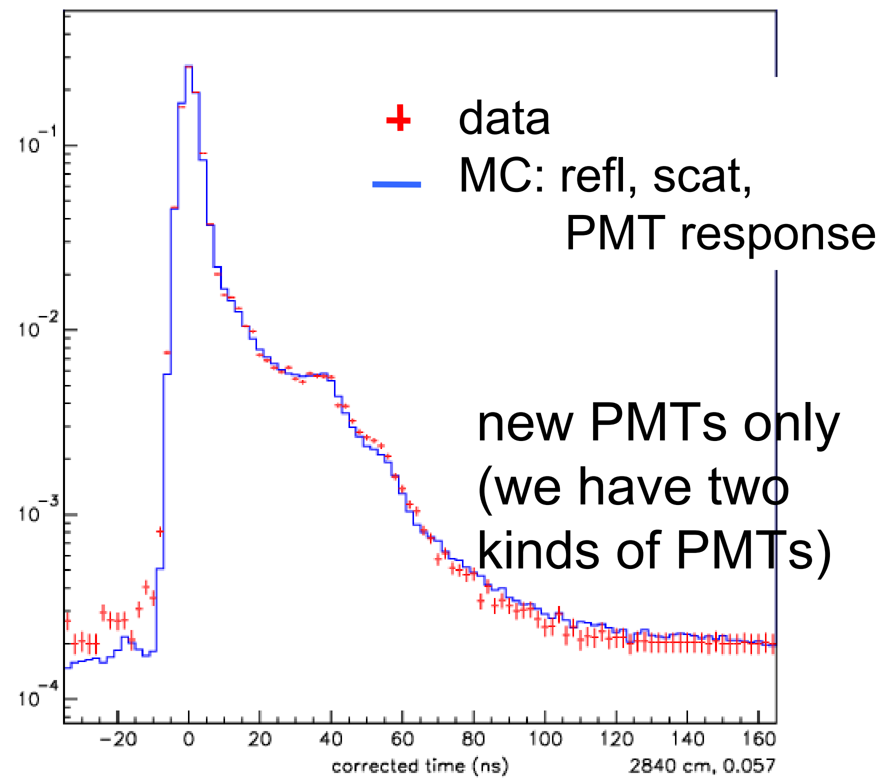
Or is it?



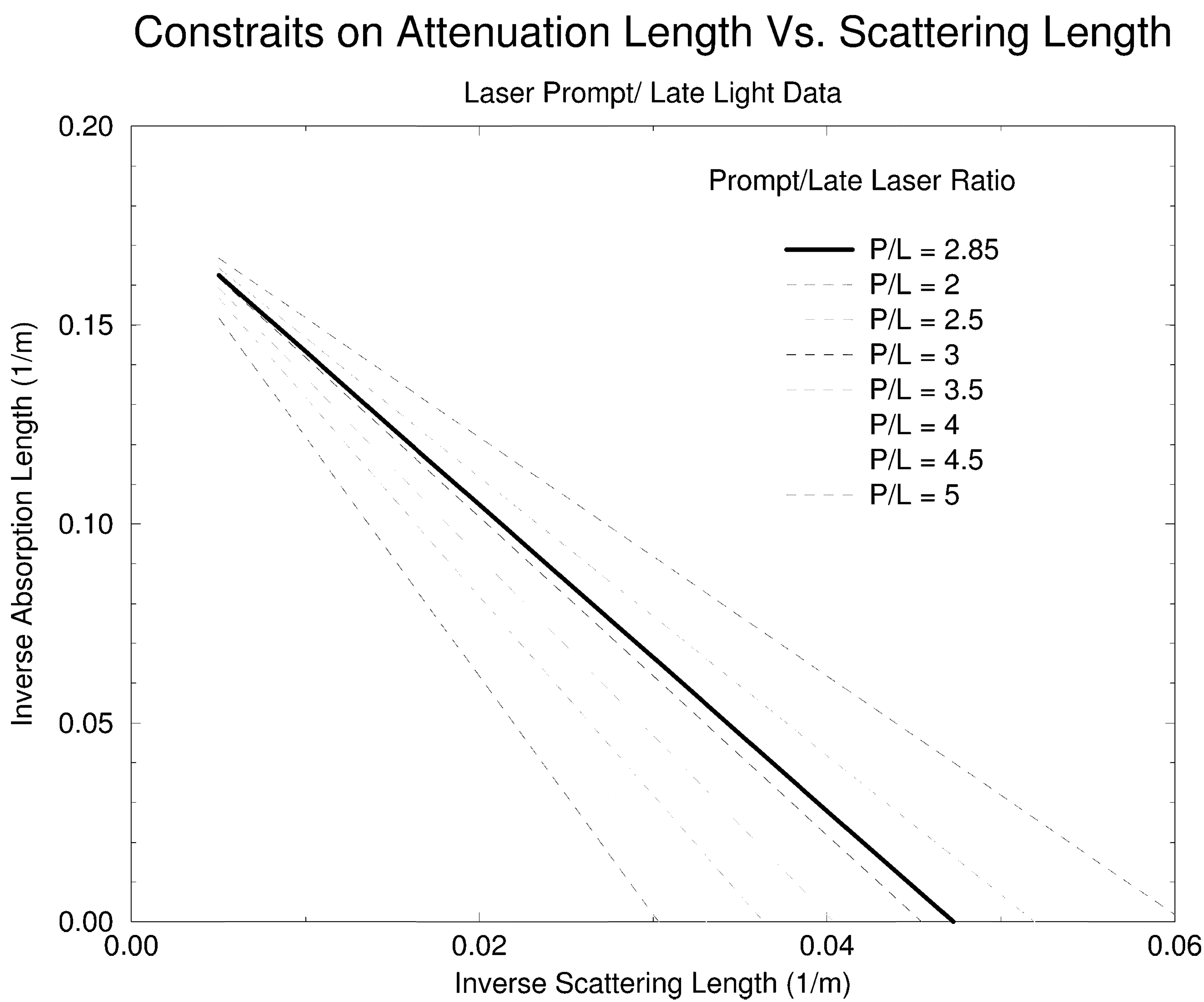
low energy
laser photons
should not
induce scintillation

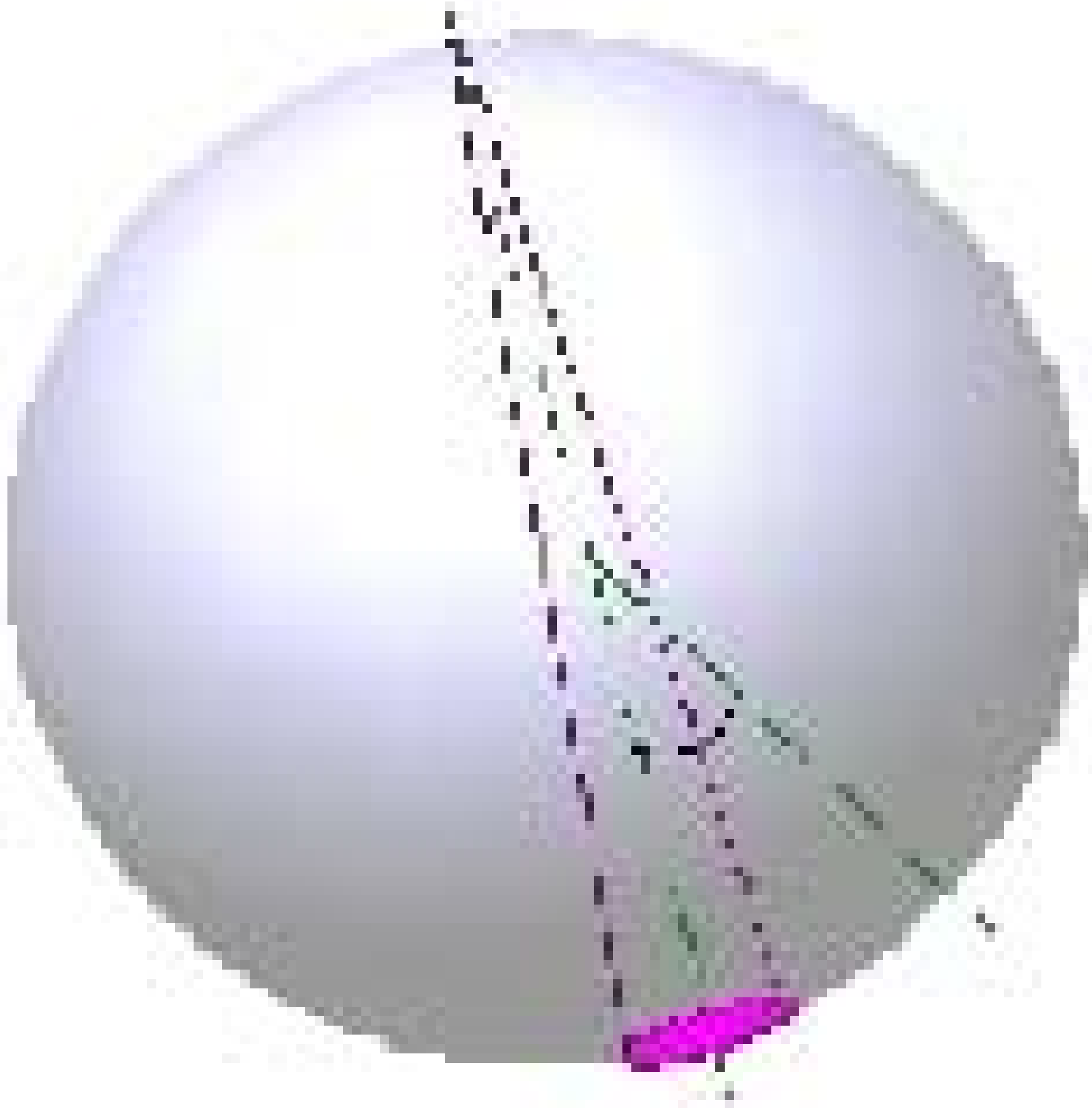
Modeling “late light”

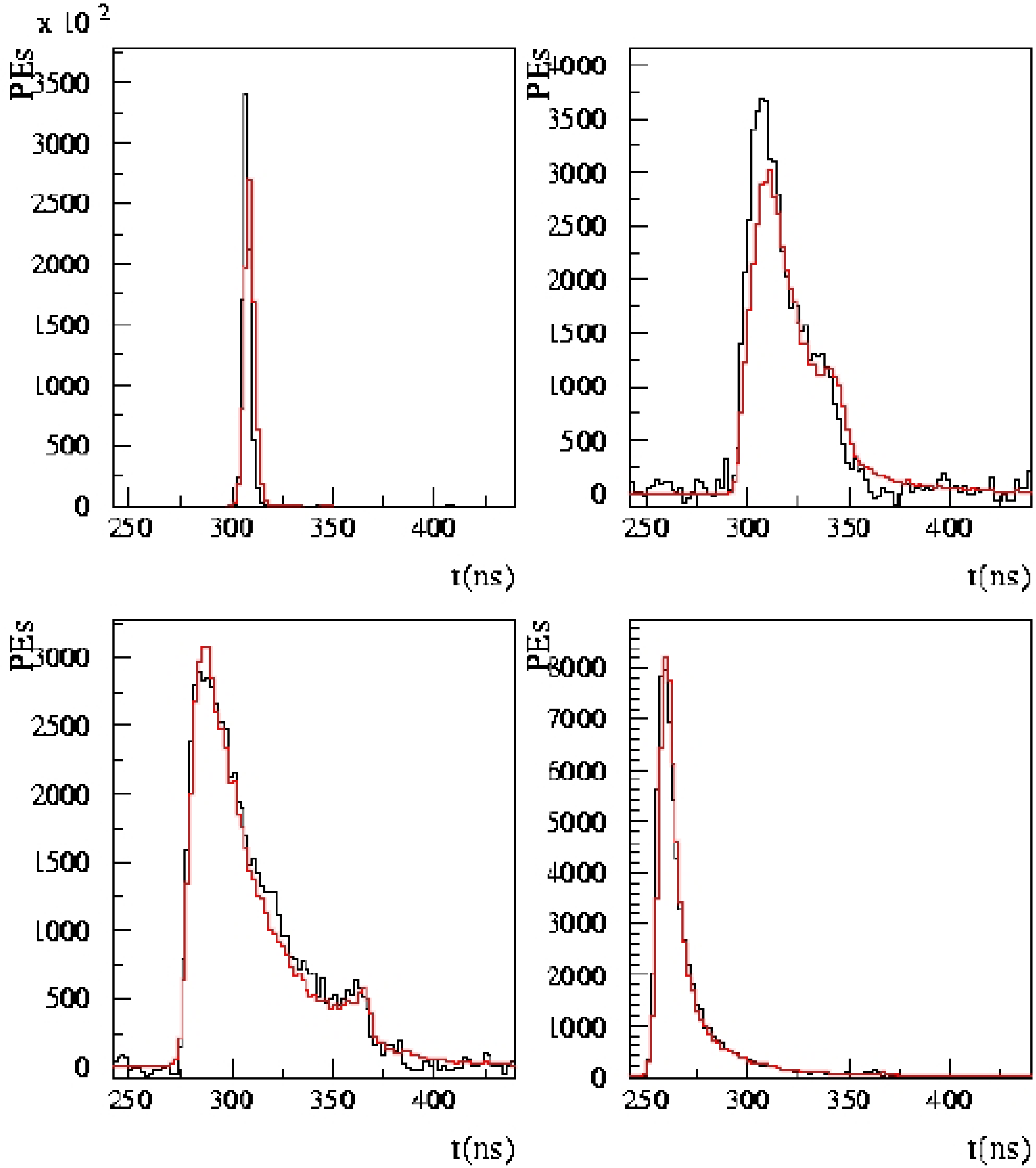




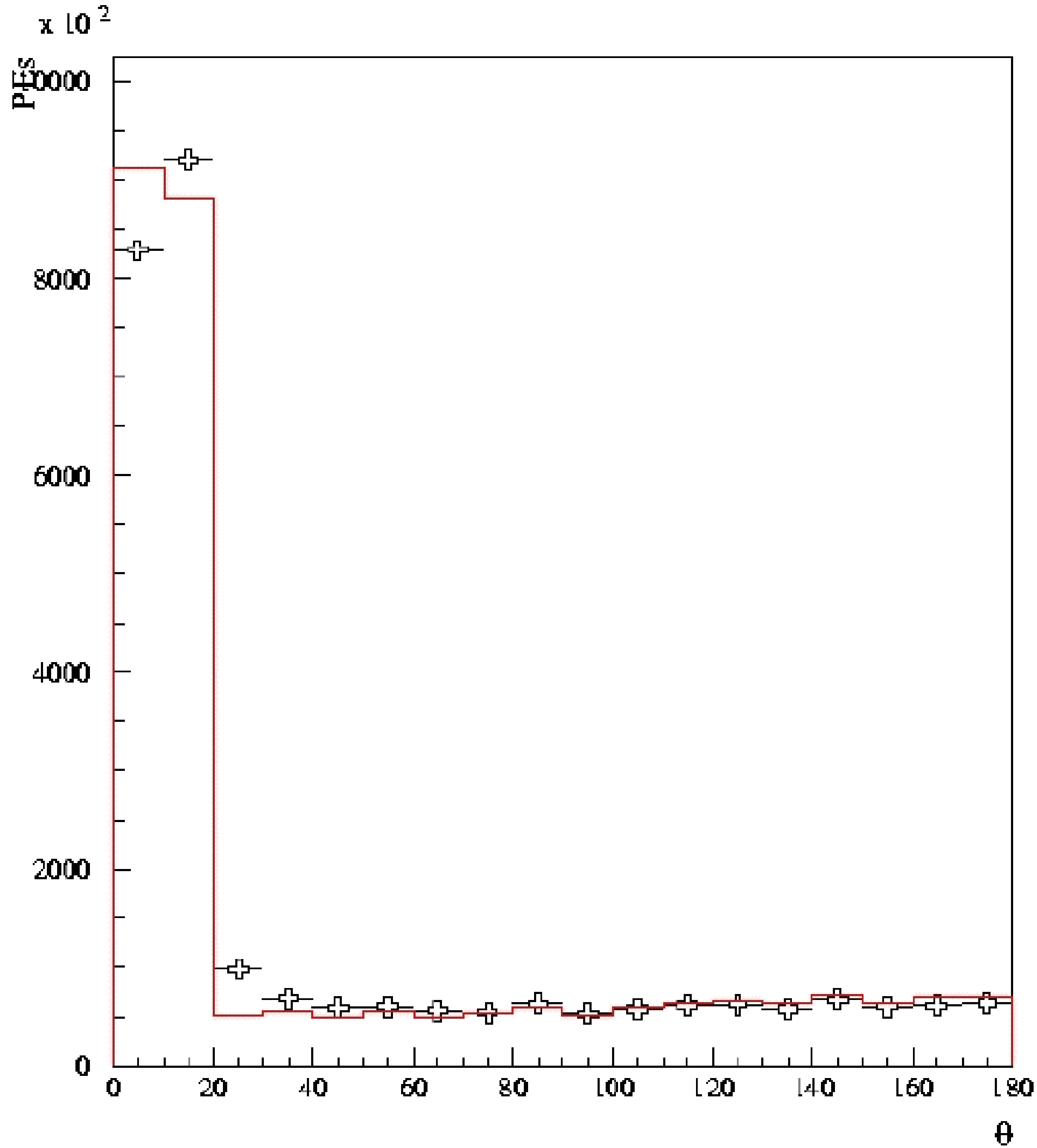
…and scintillation will sit on top of this


Constraits on Attenuation Length Vs. Scattering Length
Laser Prompt/ Late Light Data
Prompt/Late Laser Ratio
P/L = 2.85
P/L = 2
P/L = 2.5
P/L = 3
P/L = 3.5
P/L = 4
P/L = 4.5
P/L = 5
Inverse Absorption Length (1/m)
0.20
0.15
0.10
0.05
0.00
0.00
0.02
0.04
0.06
Inverse Scattering Length (1/m)

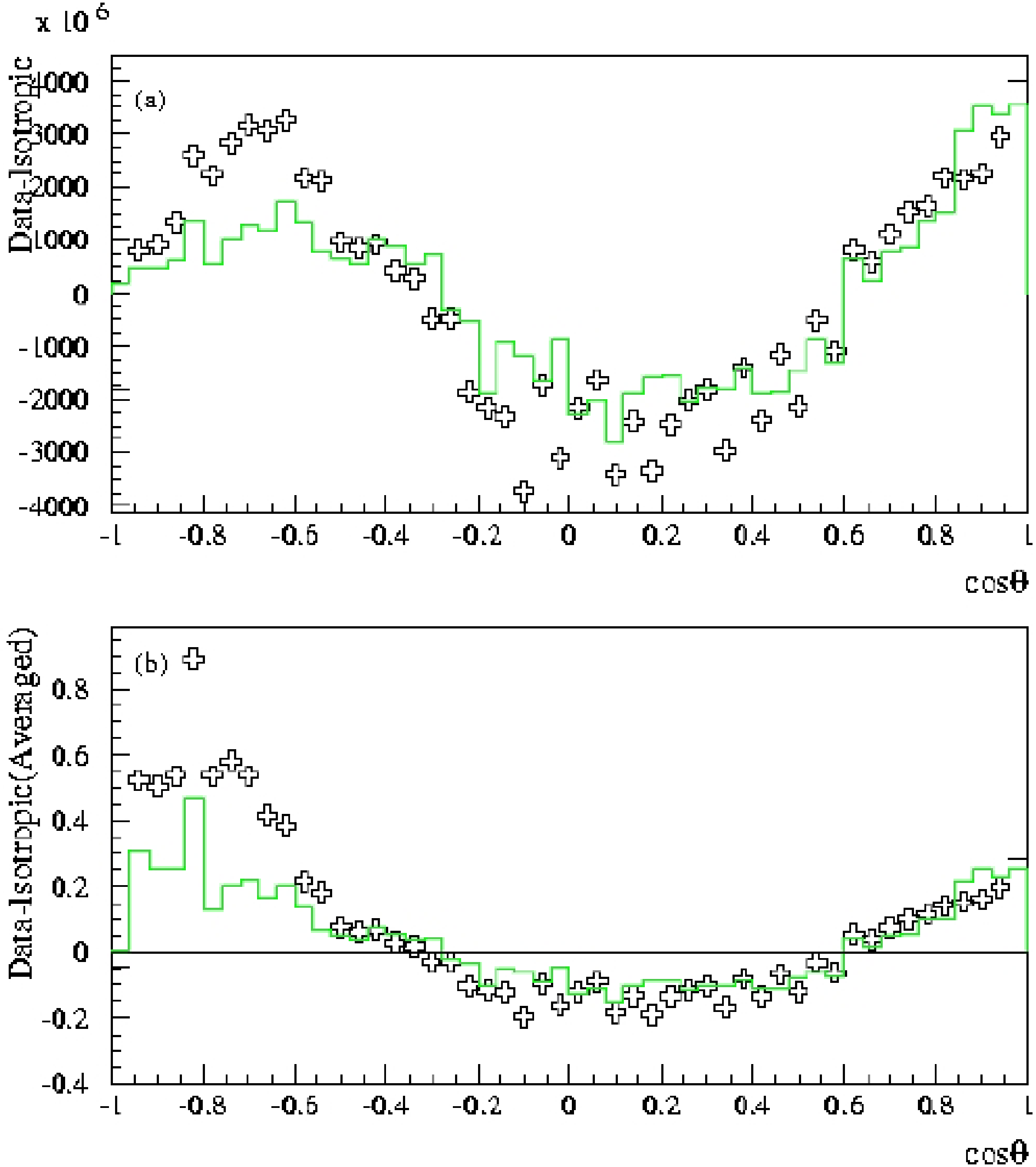




x 10 2
PEs
3500
3000
2500
2000
1500
1000
500
0
250
300
350
400
t(ns)
PEs
4000
3500
3000
2500
2000
1500
1000
500
0
250
300
350
400
t(ns)
PEs
3000
2500
2000
1500
1000
500
0
250
300
350
400
t(ns)
PEs
8000
7000
6000
5000
4000
3000
2000
1000
0
250
300
350
400
t(ns)



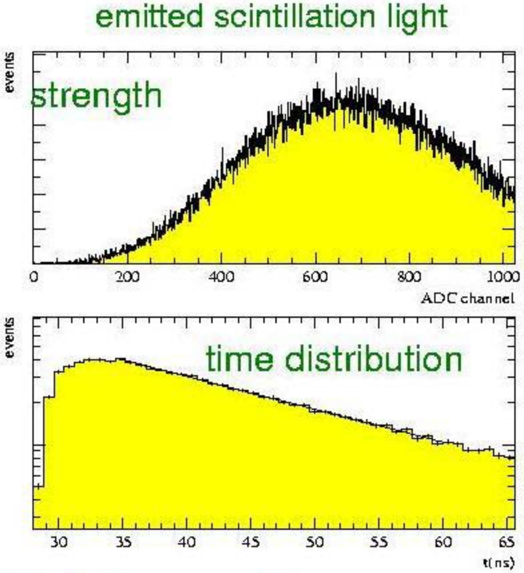
x 10 2
PEs
10000
8000
6000
4000
2000
0
0
20
40
60
80
100
120
140
160
180
θ



x 10^6
(a)
Data-Isotropic
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
cosθ
(b)
Data-Isotropic(Averaged)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
cosθ

MiniBooNE Oil Tests

Scintillation light from MiniBooNE Marcol 7 mineral oil has been measured using the Indiana University Cyclotron Facility 200 MeV proton test beam.



Preliminary results:
- ~5.0 PEs/MeV deposited for 100% solid angle
- $\tau \sim 20$ns

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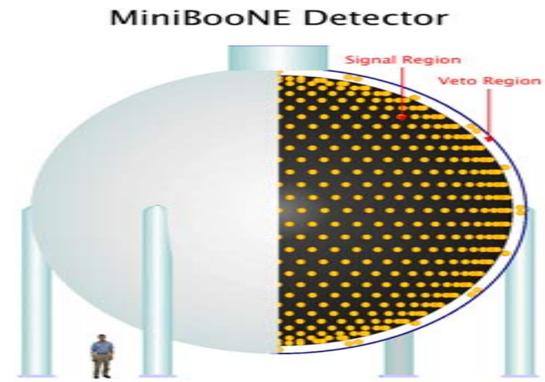

Summary

- Cherenkov Light Yield as Expected
- Scintillation Light Observed (to be studied)
- Attenuation Length > 20 m at 460 nm
- Attenuation Length ~ 10 m at 397 nm
- Absorption and Scattering Comparable at these wavelengths
- Calibration with Lasers, Cosmic Muons and decay electrons proceeding as planned